Challenges to the future of zero emissions electric power

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Overview-Learnings from WECC studies on futures for reliable power

- It is technically feasible to get to a very clean zero emission power supply system over the next 20 to 30 years.
- Key issues arise in terms of: the time frame, the costs, the rules and regulatory changes needed, the shifts in consumer expectations, and the impacts on electricity-intensive industries.
- On a full lifecycle costs and emissions basis, it is unclear what contributions this will make to addressing climate change concerns.
- Much of this portends a minefield over the next 20 years or more for capital markets and investors.

Overview of western electric coordinating council

The Western Electricity Coordinating Council (WECC) is a non-profit corporation that exists to assure a reliable Bulk Electric System in the geographic area known as the Western Interconnection. WECC has been approved by the Federal Energy Regulatory Commission (FERC) as the Regional Entity for the Western Interconnection. The North American Electric Reliability Corporation (NERC) delegated some of its authority to create, monitor, and enforce reliability standards to WECC through a Delegation Agreement.

WECC Reliability Studies- What are they about?

- The Western Electric Coordinating Council is the Federally established reliability agency for the Western United States (with two western provinces of Canada cooperating). The core job is to involve utilities and other key players (power plant and transmission system owners, regulatory agencies, etc.) in short and long term studies and analyses that support the reliability of the bulk transmission system in the West (avoid blackouts).
- Each year or two they do perform scenario and sensitivity analysis using a range of forecasts and models to understand risks that may emerge in the 10 year and 20 time frames.
- Quantum Planning Group has served as the lead consultant for scenario analyses for WECC since 2011. We have assisted in all phases including creating scenarios, data gathering for modeling, assessing model results and creating analytical reports to the public and key stakeholders.

Some basics of WECC modeling for reliability

- Core tools are a production cost model (PCM) and power flow (PF) model. The PCM seeks to show if sufficient power supply resources are available at a given time to meeting demand and minimize unserved energy. The PF model shows if the grid and all of its flows are working well at a given time and there are no issues with power quality.
- "At a given time" means these are both snap shot models. With that very often a high demand peak time is chosen to test for reliability issues.
- The models use a lot of data from power serving entities. WECC starts with an anchor data set (which has a lot of assumptions built into it) and then varies those inputs to run tests. WECC can also change key variables in the models such as fuel prices, cost of carbon, cost of money, etc. to assess changes over time. Other data is gathered from sources such as DOE, NREL and others.

The 2020-2021 WECC Reliability Studies

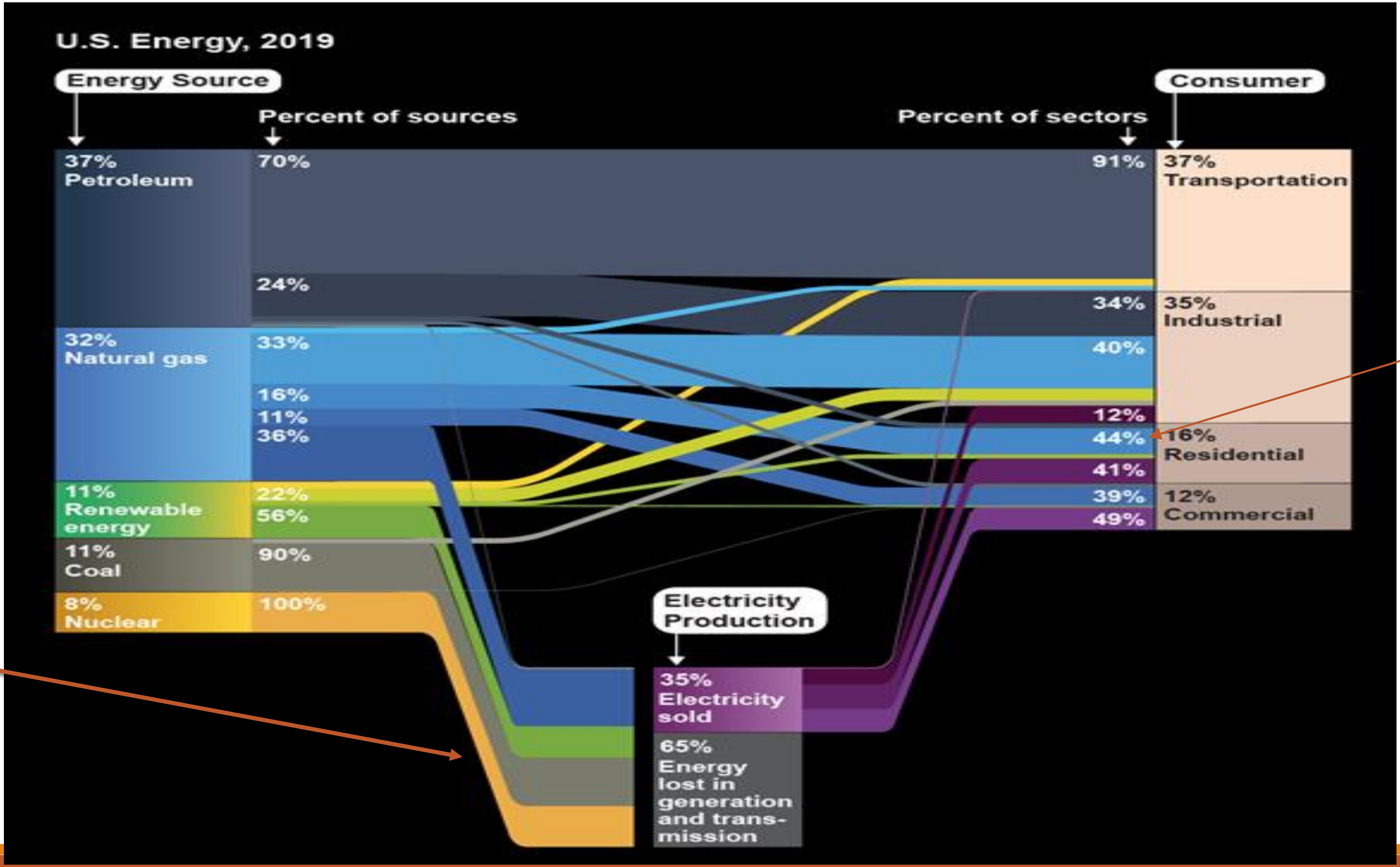
During this study cycle there were several study groups looking at the following areas:

- A 20 year look at how to get to zero carbon emission power system in the West
- The role in integrating distributed energy resources
- Shifts in loads and demand based on environmental conditions (high temperatures)
- Risks to system inertia with the loss of key resources

For this group, we discuss the key results from the first two study areas above.

Setting some context-Addressing carbon emissions is far bigger than a electric industry problem

Figure 2 2019 US Energy Component Sources, *Source: Scientific American, "Can natural Gas be Part of a Clean Energy Future?"* April 2021



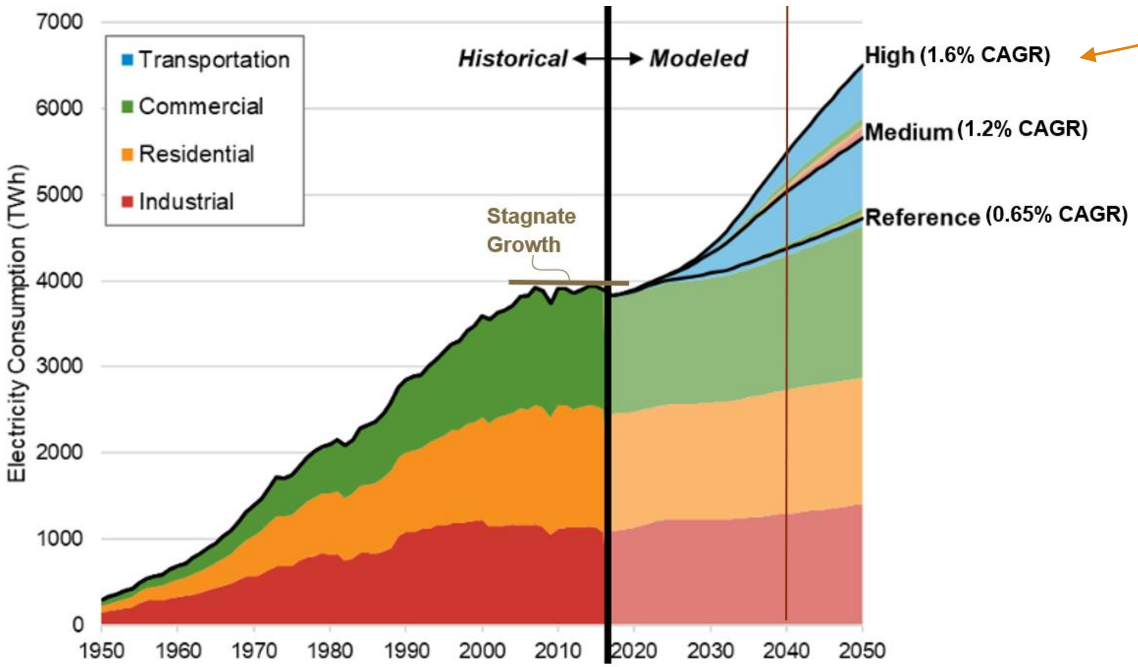
See how we use electricity.

We have forgotten how hard it is to produce and transmit electric power.

Assumption on Energy Demand Growth

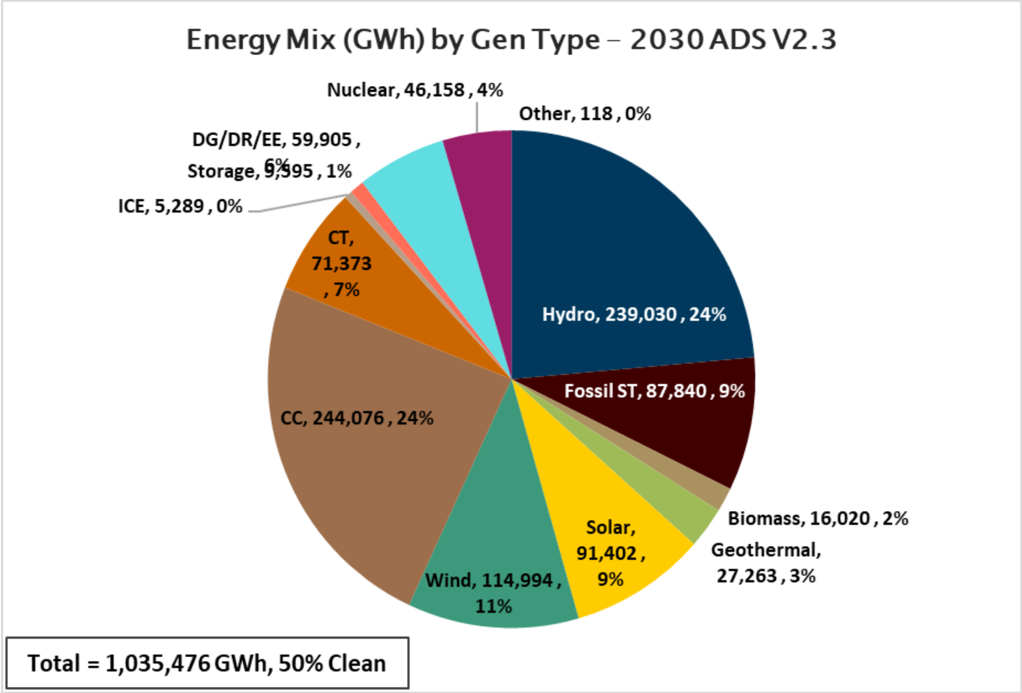
What if power demand rises faster than we expect due to faster adoption of EVs, use of crypto currency, and electrification of housing and industry. Can we accelerate coal and gas retirements while this is occurring?

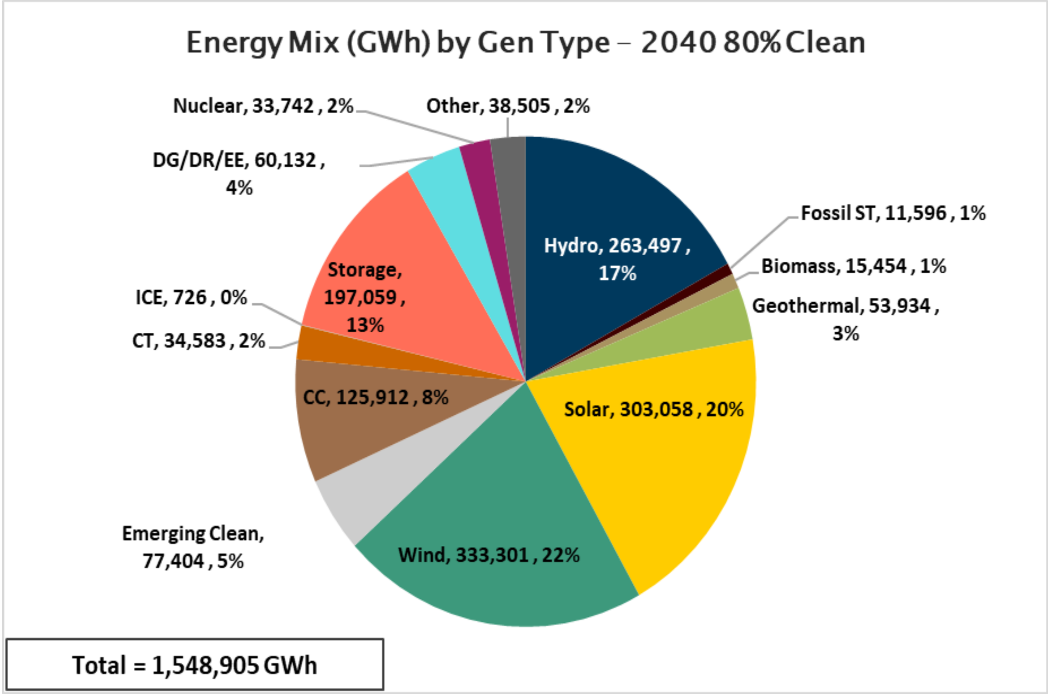
Figure 2: EFS—Electricity consumption growth potential [8]



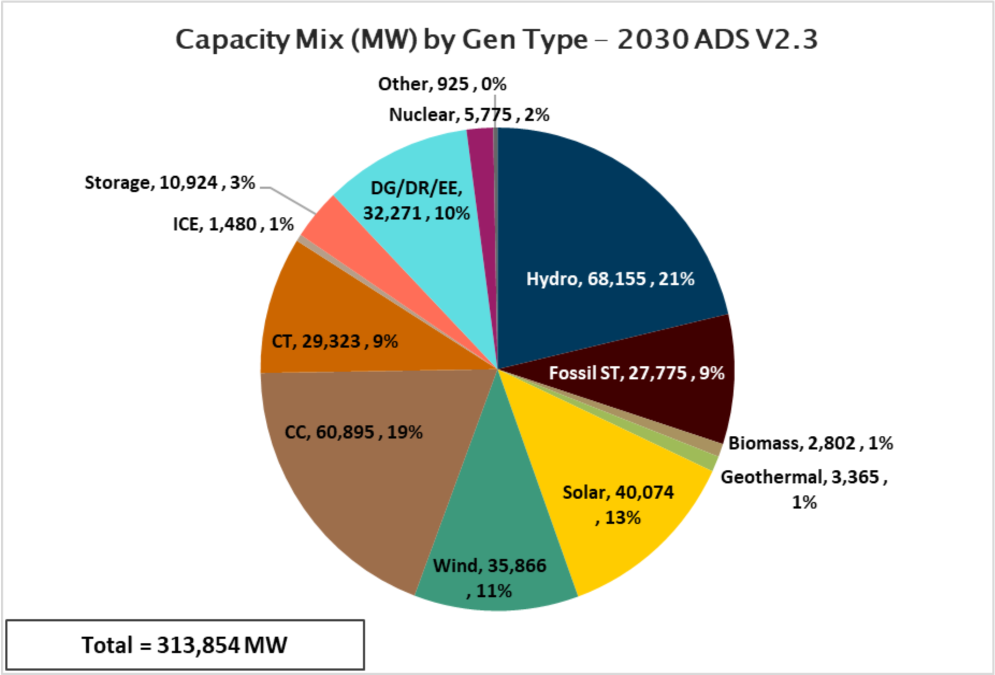
WECC looked at the highest growth forecast.

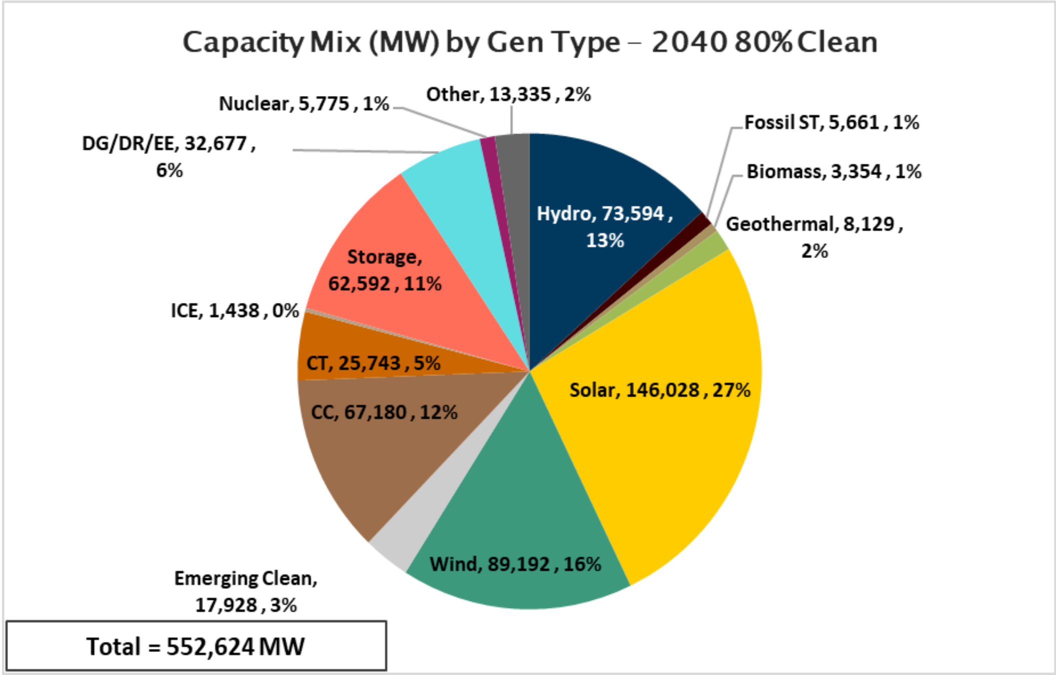
Model results for Power Supply -20 years out
Energy needed (with growth)





Model results for Power Supply -20 years out Generation capacity needed (with growth)

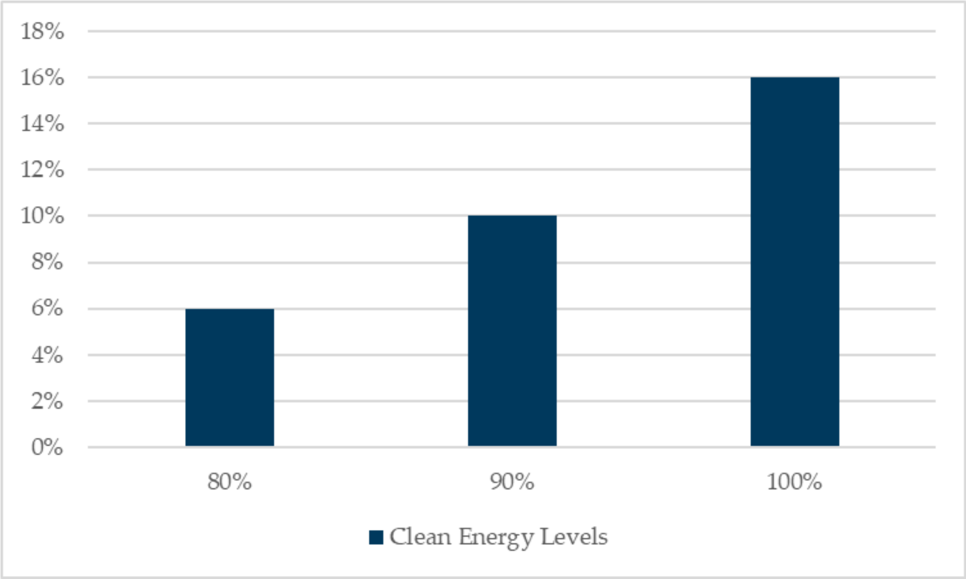




The key issue is: What is that "emerging clean?" Similar charts exist up to 90% Clean,

Clean energy production needed as we get cleaner

Figure 8: Emerging clean flex percentages at clean energy levels



Clean energy was modeled as equivalent to a gas plant with $10 per MBTU gas.

Key Issues 1

- There is no clear existing winner for the clean flexible power supply that works like natural gas in the past. Technology advances are being pursued, but no clear winner yet.
- What will be the fuel source and other issues related (construction, regulations, balance of plant, connection to the grid) to bringing this unknown clean flex into wide use in the industry?
- How much will this new source cost, what might be the rate impacts?
- How will the new source be financed and paid for (energy versus capacity contracts)?

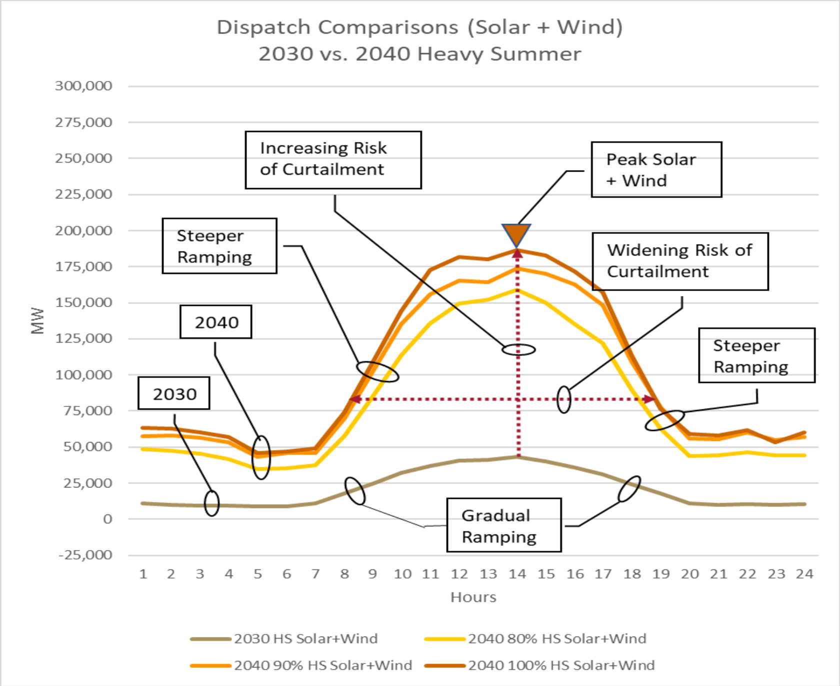
The Duck Curve Dilemma

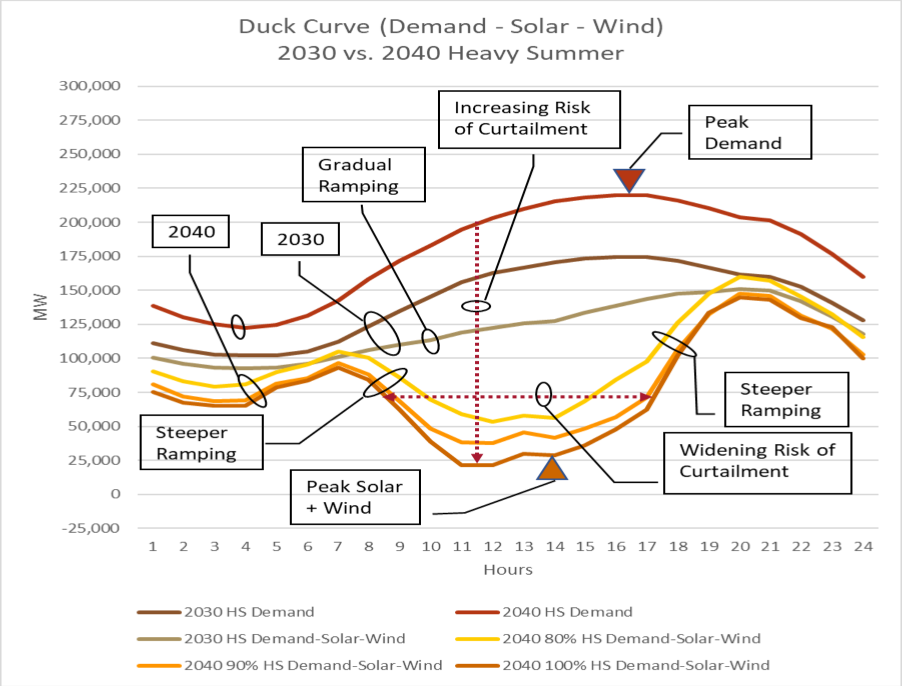
Because energy production from VRE resources do not align with load demand patterns, the risk of unserved load and curtailments increases with their use. The risks can be better understood by the use of a "duck curve" chart. The duck curve is a chart that shows the timing imbalance between hourly demand with and without offset dispatch adjustments from VRE resources. The name of the graph was coined because its shape resembles the profile of a duck.

The belly of the duck is that region in which there is abundant energy production from VRE resources when load demand is low.

The head of the duck is that region in which energy production from VRE resources drops off when load demand is high. The duck curve is constructed by subtracting the hourly dispatch of VRE resources from hourly demand. The resulting adjusted demand is that which must be served by resources other than VRE resources. Figure 5 compares heavy summer load levels and light autumn load levels for the 2030 ADS and the 2040 sensitivity cases at 80%, 90%, and 100% clean energy levels using duck curves.

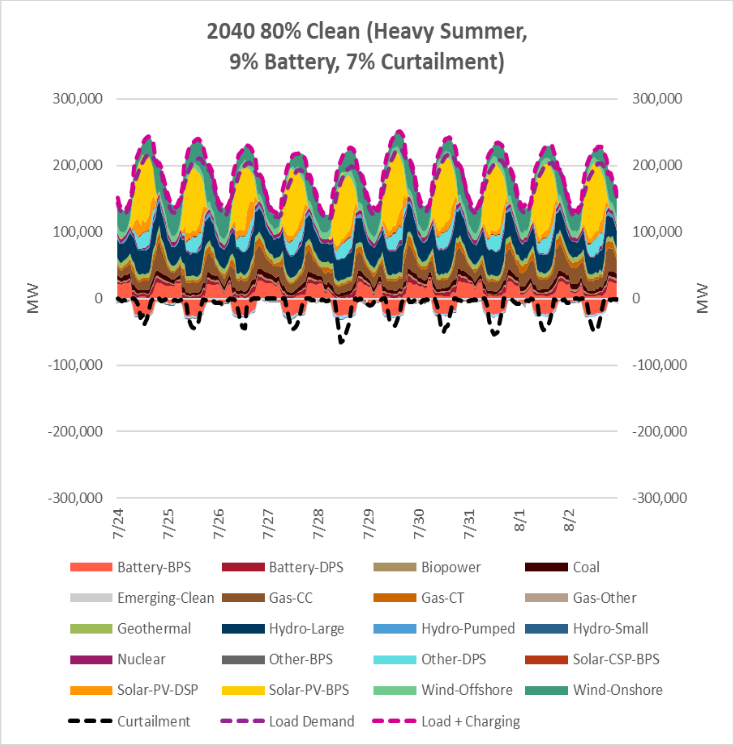
Figure 5: 2030 vs. 2040 VRE Duck Curve Comparisons

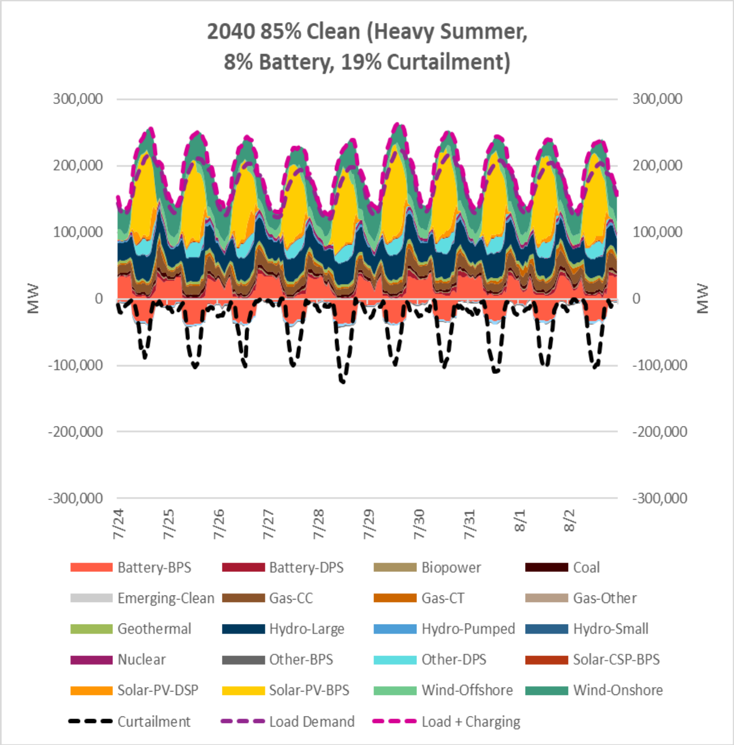




The VRE Resource Saturation Point

As the additions of solar, wind, and BESS resources were increased in the PCM progression from 80% to 100% clean energy levels, a saturation point was reached at 90% clean energy level in which curtailments became excessive and occurred at all hours of the day. While there are plenty of hours that storage can be charged under these conditions, storage could only be dispatched into curtailment hours based upon the PCM results where only BESS and VRE resources were added to reach higher clean energy levels.

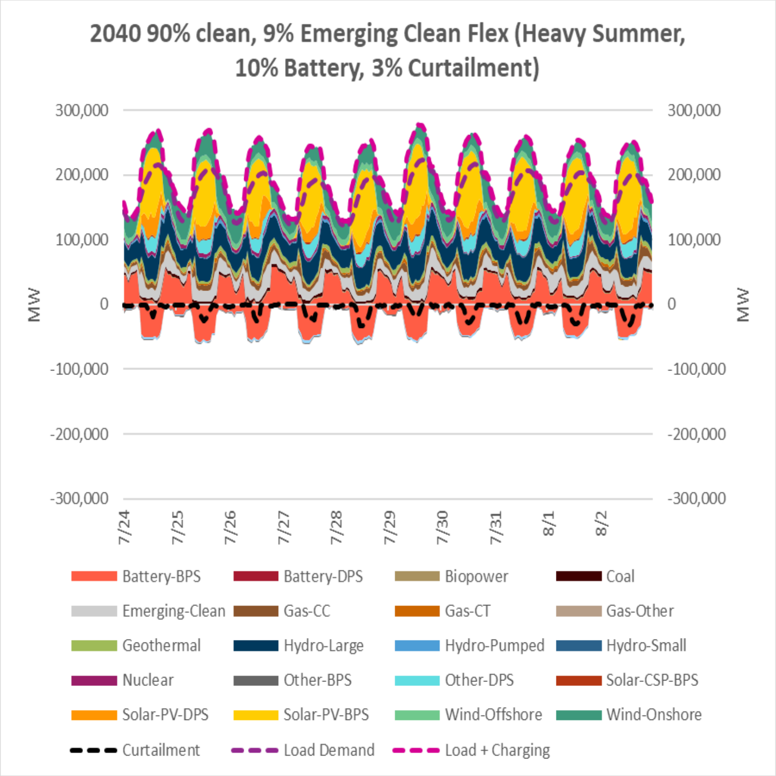




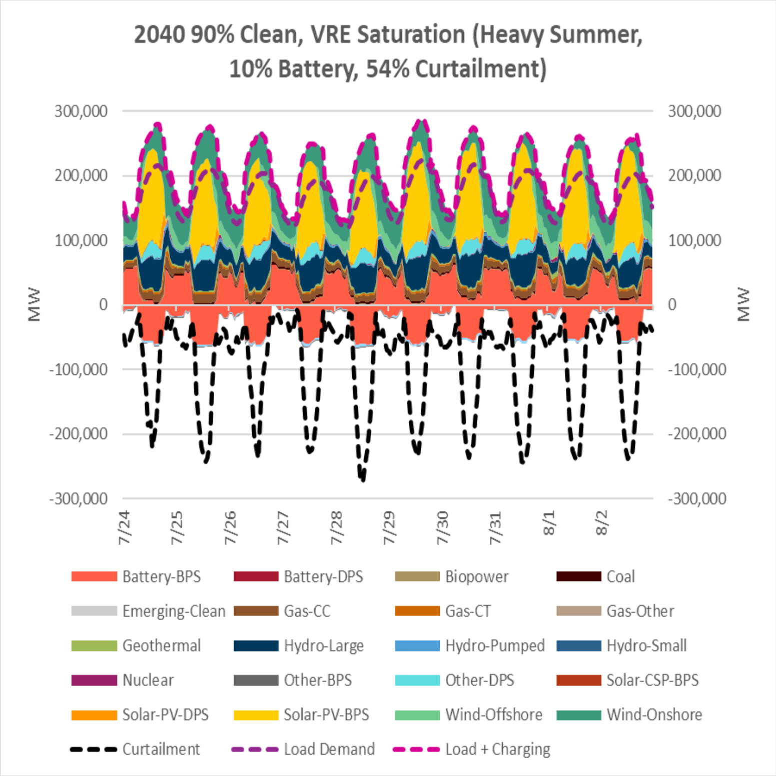
Another issue: Should we be charging EVs with battery power?

Figure 6: VRE resource saturation point / high curtailments

Adding more solar and batteries does not help.



Here we have the unknown clean flex that acts like gas.



Just force in more clean energy (solar) then what?

Key Issues 2:

- Can the grid operate with reliably in light of the peaks and valley of power demand that shift on a seasonal basis, and that vary widely by State and region? Can independent power contracts handle curtailments? If capacity payments are included, what happens to utility rates?
- WECC is also noting that reliability of the grid is no longer based on capacity of excess generation but access to more energy when needed. How does the industry adjust to this?
- What happens as we move closer to zero carbon emission in the power system? Industry reports suggest that getting from 90% clean to 100% clean means the incremental/marginal costs rise dramatically.
- What policy, regulatory and financial market changes will be needed to make sure the transition to clean power in fair, balanced, affordable and credit-worthy?
- Can all of this be done on a national basis? Or can each state decide to go at its own pace in its own way? Study by WECC on distributed energy resources (more rooftop solar) showed that a more even spread across state lines with additional transmission for trading reduced costs and increased reliability.

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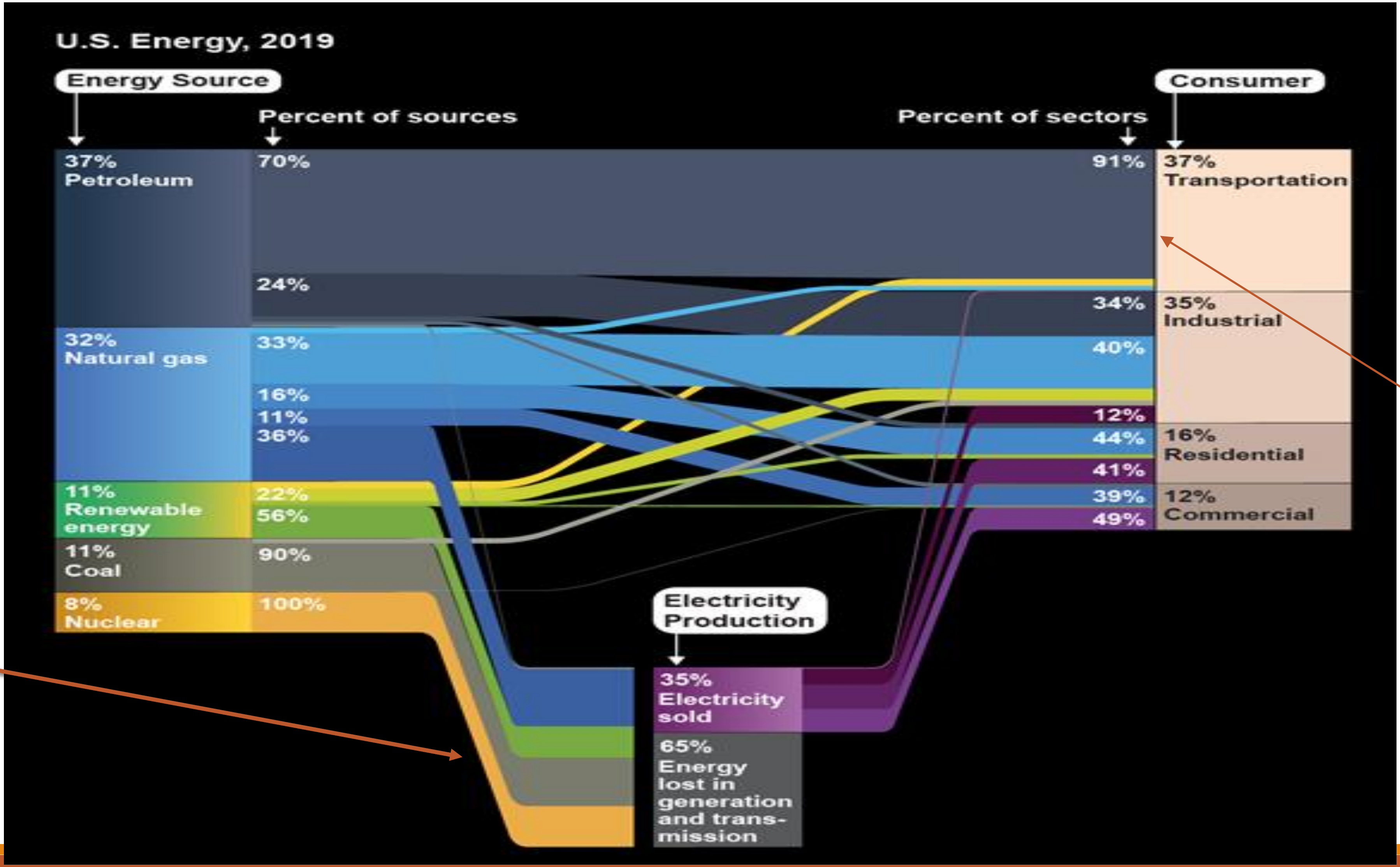
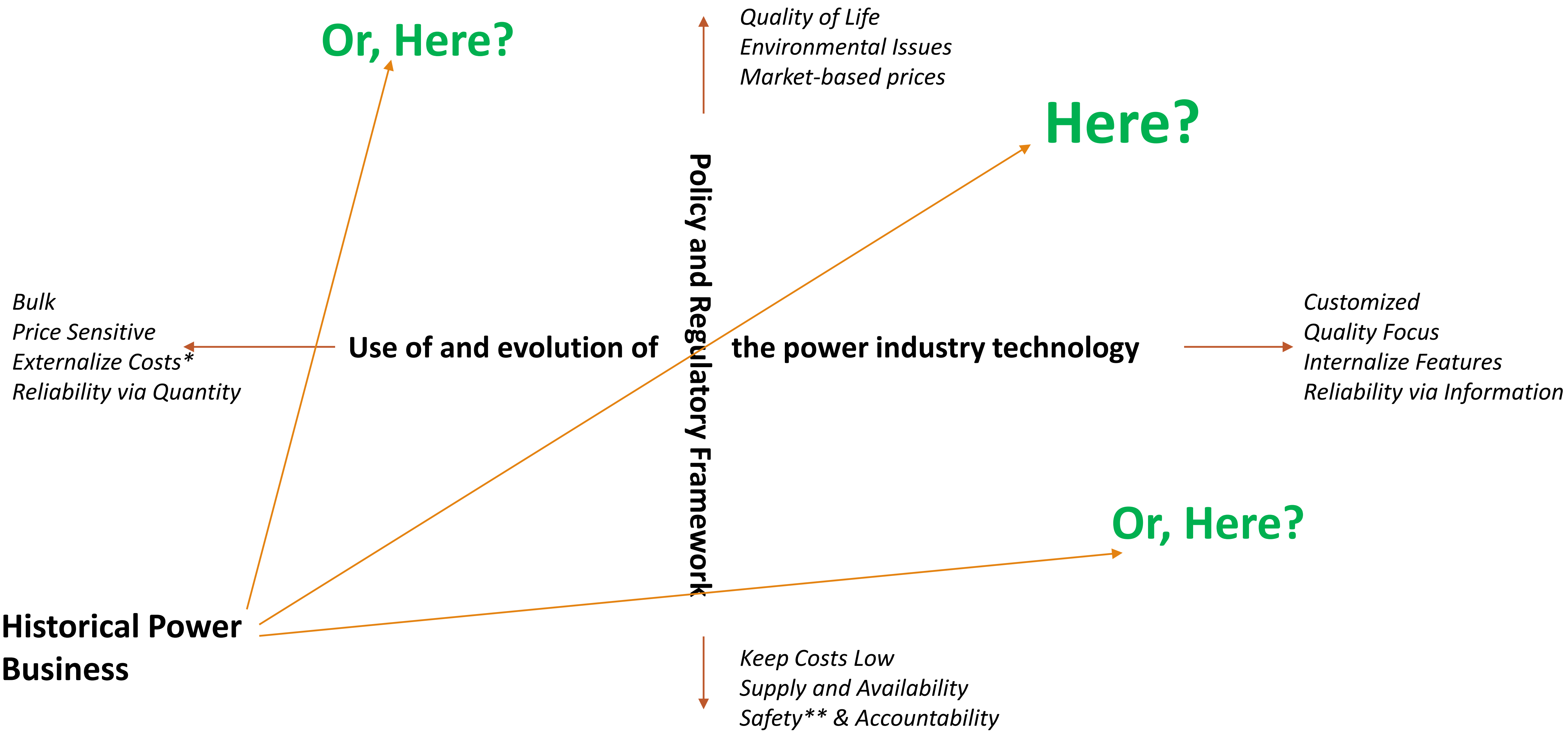


We have forgotten how hard it is to produce and transmit electric power.

In light of what we now know about a transition to zero-carbon, do we really think we can replace all of that petroleum in the transport sector with electricity and still serve other existing needs?

At what prices?

Where are we going? And, how do we get there?



*Externalize environmental costs in particular to lower costs/prices

**Safety now assumed as standard

Thank you
Q & A and discussion

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Link to full study by WECC
https://www.wecc.org/_layouts/15/WopiFrame.aspx?sourcedoc=/Administrative/2040%20Clean%20Energy%20Scenarios.pdf&action=default